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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/616,097	07/08/2003	Zhi-Wen Sun	AMAT/8241/CMP/ECP/RKK	1645

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EXAMINER

WONG, EDNA

ART UNIT	PAPER NUMBER
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1753

DATE MAILED: 06/08/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/616,097

Applicant(s)

SUN ET AL.

Examiner

Edna Wong

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-33 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-33 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on ____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. ____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. ____. |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date <u>See "Other"</u> . | 6) <input checked="" type="checkbox"/> Other: <u>See Continuation Sheet</u> . |

Continuation of Attachment(s) 6). Other: October 14, 2003; September 10, 2004; and January 13, 2005.

Claim Objections

Claims **2-4, 6, 14-16, 18, 21, 24 and 27-29** are objected to because of the following informalities:

Claim 2

line 2, the word -- of -- should be inserted after the word "consisting".

Claim 3

line 2, the word -- of -- should be inserted after the word "consisting".

Claim 4

line 2, the word "a" should be amended to the word -- the --.

Claim 6

line 2, the word "a" should be amended to the word -- the --.

Claim 14

line 2, the word -- of -- should be inserted after the word "consisting".

Claim 15

line 2, the word "a" should be amended to the word -- the --.

Claim 16

line 2, the word "a" should be amended to the word -- the --.

Claim 18

line 1, the word "a" should be amended to the word -- the --.

Claim 21

line 6, the word -- to -- should be inserted after the word "bias".

Claim 24

line 2, the word -- of -- should be inserted after the word "consisting".

Claim 27

line 1, the word "a" should be amended to the word -- the --.

Claim 28

line 2, the word "a" should be amended to the word -- the --.

Claim 29

line 2, the word "a" should be amended to the word -- the --.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

Claims **21-22, 25 and 32-33** are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 21

line 1, "the bulk-fill copper layer" lacks antecedent basis.

lines 3-4, it appears that the "second copper solution" is the same as that recited in claim 21, line 3. However, it is unclear if it is. If it is, then it is suggested that the word -- the -- be inserted after the word "wherein".

Claim 25

lines 1-4, it appears that "the copper solution comprises at least one copper source compound selected from the group ..." is further limiting the copper solution comprising copper ions and complexing compounds recited in claim 23, lines 4-5. However, it is unclear if it is. If it is, then it is suggested that the word -- further -- be inserted after the word "solution".

Claim 32

lines 1-7, it appears that “wherein depositing a bulk-fill copper layer onto the copper gap-fill layer comprises ...” is further limiting the method recited in claim 31. However, it is unclear if it is. If it is, then it is suggested that the word “wherein” be amended to the words -- further comprising --.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

- I. Claims 1-7 are rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

Miura teaches a method for depositing a copper seed layer (= reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes) [page 4, [0051]] onto a substrate surface (= a silicon wafer) [page 3, [0046]], wherein the substrate surface comprises a barrier layer (page 3, [0049]), comprising:

(a) placing the substrate surface into a copper solution, wherein the copper solution comprises complexed copper ions (page 2, [0020]) and a pH less than 7 (= a

pH of 4 to 10) [page 3, lines 0040]];

(b) applying an electrical bias to the substrate surface (page 4, [0053]); and

(c) reducing the complexed copper ions with the bias to deposit the copper seed layer onto the barrier layer (pages 3-4, [0049] to [0051]).

The barrier layer is selected from the group consisting cobalt, ruthenium, nickel, tungsten, tungsten nitride, titanium, titanium nitride and silver (page 3, [0049]).

The complexed copper ions are selected from the group consisting copper citrate, copper borate, copper tartrate, copper oxalate, copper pyrophosphate, copper acetate, copper EDTA complex and combinations thereof (page 2, [0020]).

The complexed copper ions have a concentration in a range from about 0.02 M to about 0.8 M (page 2, [0021]).

The bias is configured to generate a current density across the substrate surface that is less than about 10 mA/cm² across the substrate surface (page 4, [0053]).

The current density is in a range from about 0.5 mA/cm² to about 3 mA/cm² (page 4, [0053]).

The copper seed layer has a thickness less than about 200Å (= an average thickness of 100 to 200 nm) [page 1, [0007]].

II. Claims **11-19** are rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

Miura is as applied above and incorporated herein.

Miura also teaches a method for depositing a metal seed layer onto a barrier layer on a substrate surface, comprising:

(a) placing the substrate surface into a solution, wherein the solution is acidic (= a pH of 4 to 10) [page 3, [0040]] and comprises a metal source compound (page 2, [0020]) and a complexing compound (page 2, [0023]);

(b) forming complexed metal ions within the solution (= an electrolytic copper plating solution contains copper ions and *a complexing agent for the copper ions*) [page 2, [0019]]; and

(c) reducing the complexed metal ions with an electroplating technique to form the metal seed layer (= reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes) [page 4, [0051]].

The complexing compound has a concentration in a range from about 0.02M to about 1.6M (page 3, [0039]).

III. Claims **23-30** are rejected under 35 U.S.C. 102(e) as being anticipated by **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1).

Miura is as applied above and incorporated herein.

Miura also teaches a method for electroplating a copper seed layer to a barrier layer from a copper solution, comprising:

(a) placing a substrate surface comprising the barrier layer into fluid contact with

the copper solution, wherein the copper solution comprises copper ions (page 2, [0020]) and complexing compounds (page 2, [0023]); and

(b) reducing the copper ions with an electrical bias to form the copper seed layer (= reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes) [page 4, [0051]].

The complexing compound has a concentration in a range from about 0.02M to about 1.6M (page 3, [0039]).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

I. Claims **8-10** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 1-7 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura et al. is as applied above and incorporated herein.

Miura does not teach wherein the method further comprises depositing a gap-fill copper layer onto the copper seed layer and wherein, depositing the gap-fill layer

comprises, placing the substrate surface into a second copper solution, wherein the second copper solution includes free-copper ions; applying a second electrical bias to the substrate surface; and reducing the free-copper ions with the second electrical bias to deposit the copper gap-fill layer onto the copper seed layer; and wherein the method further comprises depositing a bulk-fill copper layer onto the copper gap-fill layer, wherein depositing the bulk-fill layer comprises, placing the substrate surface into a third copper solution, wherein third copper solution includes the free-copper ions; applying a third electrical bias to the substrate surface; and reducing the free-copper ions with the third electrical bias to deposit the copper bulk-fill layer onto the copper gap-fill layer.

However, Dubin teaches that a plating program in which an initiation, or seed layer repair, operation is performed by forcing a first forward current, a second forward current is then forced to superfill features less than 0.3 microns in width, and finally, a third forward current is forced to perform a bulk fill operation is a known conventional plating program for filling damascene structures (col. 3, line 66 to col. 4, line 10; and Fig. 2).

Thus, the invention as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Miura with wherein the method further comprises depositing a gap-fill copper layer onto the copper seed layer and wherein, depositing the gap-fill layer comprises, placing the

substrate surface into a second copper solution, wherein the second copper solution includes free-copper ions; applying a second electrical bias to the substrate surface; and reducing the free-copper ions with the second electrical bias to deposit the copper gap-fill layer onto the copper seed layer; and wherein the method further comprises depositing a bulk-fill copper layer onto the copper gap-fill layer, wherein depositing the bulk-fill layer comprises, placing the substrate surface into a third copper solution, wherein third copper solution includes the free-copper ions; applying a third electrical bias to the substrate surface; and reducing the free-copper ions with the third electrical bias to deposit the copper bulk-fill layer onto the copper gap-fill layer because:

Miura teaches that the trenches or via holes may be completely filled with copper using the electrolytic copper plating solution of his invention, *or they may be first filled halfway and then applied with a highly acidic or highly basic copper plating solution to be filled completely*. The electrolytic copper plating solution of his invention reinforces the seed layer and adds thickness to the seed layer within the trenches or via holes of silicon wafers so that a highly acidic or highly basic copper plating solution, which would otherwise corrode the seed layer, can be used to plate the silicon wafer (page 4, [0051]).

Highly acidic and highly basic copper plating solutions are known in the art. Nagai teaches a highly acidic copper plating solution (col. 19, Table 2). The copper sulfate would have provided free-copper ions.

Modifying the halfway fill to comprise a second forward current (and bias) and the

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complete fill to comprise a third forward current (and bias) would have eliminated thin seed layer dissolution and would have superfilled the smallest features first and then the largest features in order to provide the desired surface morphology as taught by Dubin (col. 3, line 66 to col. 4, line 10; col. 7, lines 12-38; and Figs. 2 and 7).

Furthermore, it has been shown that the transpositioning of varying steps, or varying the details of a process, as by adding a step or splitting one step into two does not avoid obviousness where the processes are substantially identical or equivalent in terms of function, manner and result. *General Foods Corp. v. Perk Foods Co.* (DC NIII 1968) (157 USPQ 14); *Malignani v. Germania Electric Lamp Co.*, 169 F. 299, 301 (D.N.J. 1909); *Matrix Contrast Corp. v. George Kellar*, 34 F.2d 510, 512, 2 USPQ 400, 402-403 (E.D.N.Y 1929); *Hammerschlag Mfg. Co. v. Bancroft*, 32 F. 585, 589 (N.D.III.1887); *Procter & Gamble Mfg. Co. v. Refining*, 135 F.2d 900, 909, 57 USPQ 505, 513-514 (4th Cir. 1943); *Matherson-Selig Co. v. Carl Gorr Color Gard, Inc.*, 154 USPQ 265, 276 (N.D.III.1967).

As to wherein at least one leveling agent is added to the second copper solution to form the third copper solution, adding at least one leveling agent to the second copper solution would have retarded the growth of plating at the inlet of a fine recess and made it possible to fully fill the fine recess with copper uniformly without the formation of any void, and further flatten the plating surface as taught by Nagai (co. 17, line 64 to col. 18, line 2).

II. Claims **20-22** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 11-19 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura et al., Dubin et al. and Nagai et al. are as applied above and incorporated herein.

III. Claims **31-33** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Miura et al.** (US Patent Application Publication No. 2003/0155247 A1) as applied to claims 23-30 above, and further in view of **Dubin et al.** (US Patent No. 6,432,821) and **Nagai et al.** (US Patent No. 6,709,563 B2).

Miura et al., Dubin et al. and Nagai et al. are as applied above and incorporated herein.

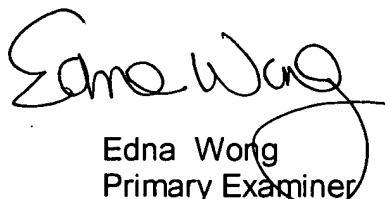
Any inquiry concerning this communication or earlier communications from the examiner should be directed to Edna Wong whose telephone number is (571) 272-1349. The examiner can normally be reached on Mon-Fri 7:30 am to 4:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (571) 272-1342. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the

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Edna Wong
Primary Examiner
Art Unit 1753

EW
June 2, 2005